Dynamic model for proliferative growth in cell structures of plant type

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Bipolar growth is a necessary attribute of most plants. In essence, bipolar growth means that the plant stem grows upwards, while the root grows downwards, drilling into the earth. It is known that to multiply, plant cells need two hormones: auxin and cytokinin. It is important that these hormones are synthesized primarily on the poles of a plant: auxin in cells at the top of the stem, and cytokinin in cells at the tip of the root. By transport channels, auxins move down, while cytokinins move upwards. The role of the hormonal countercurrent in organizing growth processes is poorly studied. We cannot experimentally single out the auxin-cytokinin countercurrent circuit and study its function for a plant growth. To solve such problem, it is more suitable to use modeling, i.e., design various models, including mathematical ones, and perform computations. The purpose of this work is to create a model of proliferative growth in a cell structure of vegetative type. As a result, we have developed a model in which bihormonal circuit controls the proliferative growth of a cell structure of vegetative type.

Prerequisites from plant physiology and a prototype of our model have been published earlier [1,2]; ?rst modeling results have also been presented [3]. The cell structure model of vegetative type in these works is a one-dimensional chain of identical cells that form a transport system for two cell division activating hormones. In the model, the cells themselves constitute hormone transport channels.

Plant growth by cell proliferation is a process running in time. Thus, it is reasonable to model the temporal dynamics of this process. To do so, we have to describe mathematically, at least in a crude approximation, the time course of cellular processes: hormone synthesis, transport and degradation. For simplicity we did not consider the duration of the cell division process. The model de?nes conditions when a cell can divide and then re?ects changes in cell structure parameters resulting from cell division: the appearance of new cells and changes in hormone concentration in each cell of the multicellular row.

To build the model, we have used control theory methods. For the original model, processes of synthesis, transport, and inactivation of hormones for internal or terminal cell were described as a system of linear differential equations where time is the independent variable [4]. Then the obtained systems of equations were represented as a certain number of standard graphical elements (dynamic links) connected with each other. Thus, for an internal and a terminal cells we have created virtual contours simulating the dynamics of hormone concentration. Then these contours were supplemented with the cell division control units. Finally, on a basis of the obtained contours we have constructed a general modeling scheme of the growing cell structure where cells were connected by transport channels for hormones *A* (auxin) and *C* (cytokinin) moving in opposite directions. According to the modeling scheme, we have developed a system of ?nite difference equations. Based on this system, we have obtained computational formulas for the modi?ed Euler method. The resulting model determines the dynamics of hormone concentration and the growth parameters of the linear cell structure growing via cell division. The growth characteristics of the model – limited linear growth and localization of cell divisions in terminal zones of the multicellular structure – closely resemble analogous characteristics of natural plants.

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